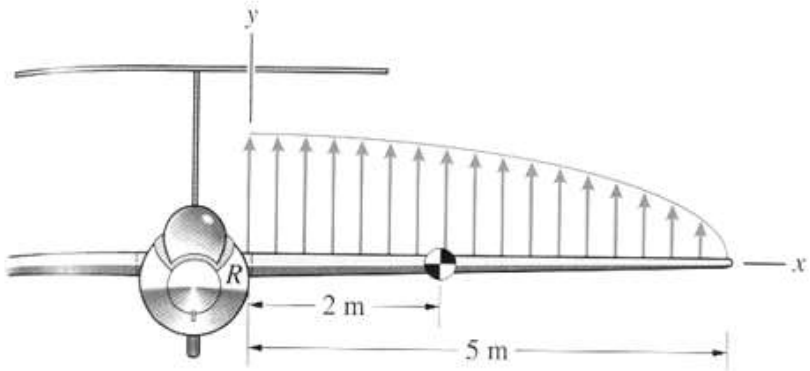
1. The aerodynamic lift of the wing is described by the distributed load of

$w = -300\sqrt{1-0.04x^2}$ N/m. The mass of the wing is 27 Kg, and its center of mass is located 2 m from the wing root *R*.



a. Determine the magnitude of the force and the moment about *R* exerted by the lift of the wing.

The magnitude of the force F is equal to the area between the curve of

$w = -300\sqrt{1-0.04x^2}$ and x-axis. Thus

$$F = -\int_0^5 300\sqrt{1^2-(0.2x)^2}\,dx = -300\int_0^1\sqrt{1^2-y^2}\cdot 5dy = -1500\int_0^1\sqrt{1^2-y^2}\,dy$$

$$= -1500\left\{\frac{1}{2}\left[y\sqrt{1^2-y^2}+1^2\cdot\arcsin\left(\frac{y}{1}\right)\right]\right\}\Bigg|_0^1 = -1500\frac{1}{2}(\arcsin(1)-\arcsin(0)) = -1500\frac{\pi}{4} = -375\pi$$

The magnitude of the Moment M is equal to the following

$$M = \int_0^5 x\cdot w\,dx = -300\int_0^5 x\cdot\sqrt{1^2-(0.2x)^2}\,dx = -7500\int_0^1 y\cdot\sqrt{1^2-y^2}\,dy = -7500\int_0^{\pi/2}\sin t\cos^2 t\,dt$$

$$= -7500\int_0^{\pi/2}\left(\sin t-\sin^3 t\right)dt = -7500\left(-\cos t+\frac{2}{3}\cos t\right)\Bigg|_0^{\pi/2} = -7500\left(1-\frac{2}{3}\right) = \frac{7500}{3} = -2500N\cdot m$$

The location of the center of lift force is as follows

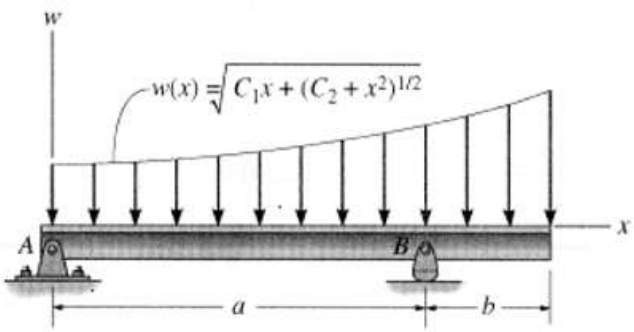
$$\bar{x} = \frac{M}{F} = \frac{2500}{375\pi} = 2.122m$$

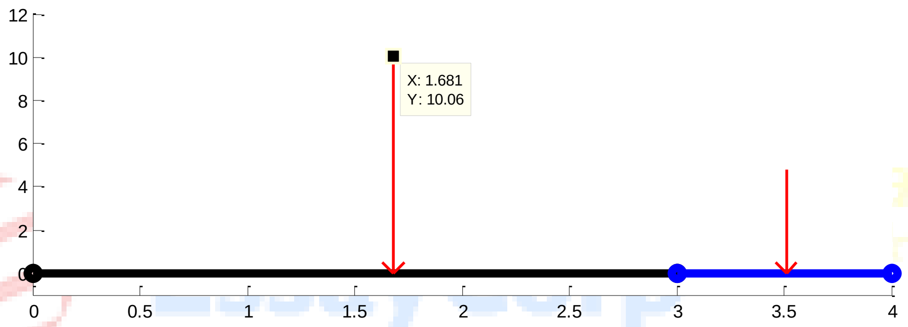
b. Determine the reactions on the wing at *R*.

Reaction force: $-(F+mg) = 375\pi - 27\cdot 9.8 = 913.5\text{N}$

Reaction moment: $\text{-M} - (M+mg\cdot 2) = 2500 - 27\cdot 9.8\cdot 2 = 2500 - 529.2 = \text{-1970.8N}\cdot\text{m}$

2. Given a beam under distributed loads, develop a MATLAB program to determine the equivalent resultant force of the distributed loading and its location, measure from point A. (Hint: type 'help quad' in MATLAB command window, and read the description) Use the values, $C_1=5$, $C_2=16$, $a = 3$ and $b = 1$.






```
c2 = 15;
a = 3;
b = 1;
pi=acos(-1);

% distribtion load function
W = @(x)sqrt(c1*x+sqrt(c2+x.^2));
% distribtion moment function
M = @(x)x.*sqrt(c1*x+sqrt(c2+x.^2));
% F = @(x)300*sqrt(1-0.04*x.^2);
% F = @(x)300*x.*sqrt(1-0.04*x.^2);
hold on;
plot([0,a],[0,0],'o-k','linewidth',5);
plot([a,a+b],[0,0],'o-b','linewidth',5);

Fa = quad(W,0,a);
Xca = quad(M,0,a)/Fa;
disp(['equivalent resultant force in a = ',num2str(Fa)]);
disp(['The location of center = ',num2str(Xca)]);

Fb = quad(W,a,a+b);
Xcb = quad(M,a,a+b)/Fb;
disp(['equivalent resultant force in b = ',num2str(Fb)]);
disp(['The location of center = ',num2str(Xcb)]);
```

```
equivalent resultant force in a = 10.0556
The location of center = 1.6814
equivalent resultant force in b = 4.7639
The location of center = 3.5104
```

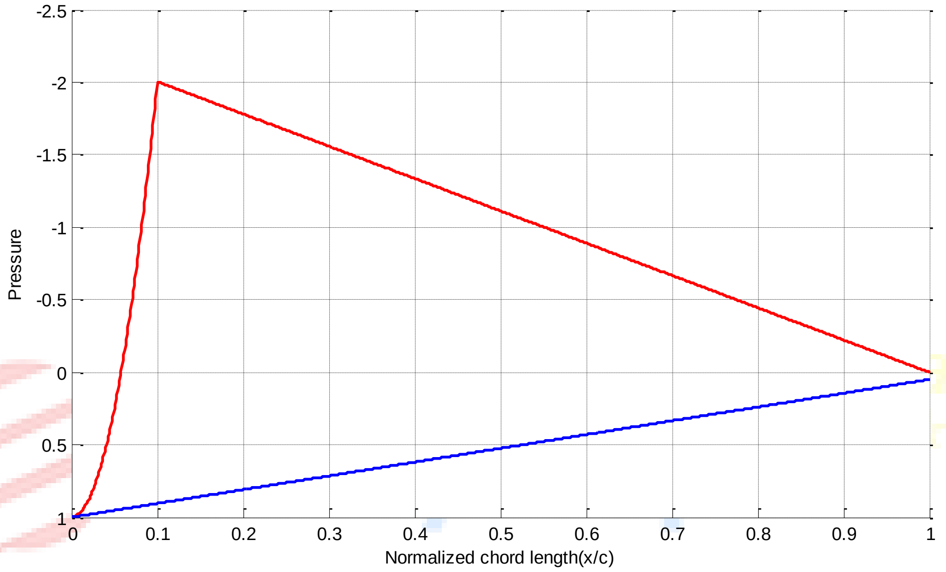
3. Consider an airfoil with chord length c and running distance x measured along the chord. The leading edge is located at $(x/c) = 0$ and the trailing edge at $(x/c) = 1$. The pressure coefficient variations over the upper and lower surfaces are given, respectively, as

$$C_{p,u} = 1 - 300\left(\frac{x}{c}\right)^2 \quad \text{for} \quad 0 \le \left(\frac{x}{c}\right) \le 0.1$$

$$C_{p,u} = -2.2277 + 2.2777\left(\frac{x}{c}\right) \quad \text{for} \quad 0.1 \le \left(\frac{x}{c}\right) \le 1.0$$

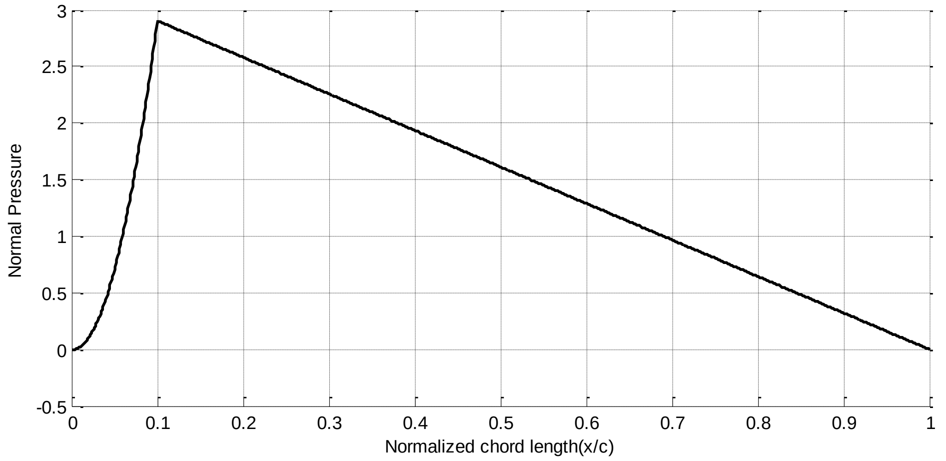
$$C_{p,l} = 1 - 0.95\left(\frac{x}{c}\right) \quad \text{for} \quad 0 \le \left(\frac{x}{c}\right) \le 1.0$$

a. Using MATLAB, plot the pressure distribution

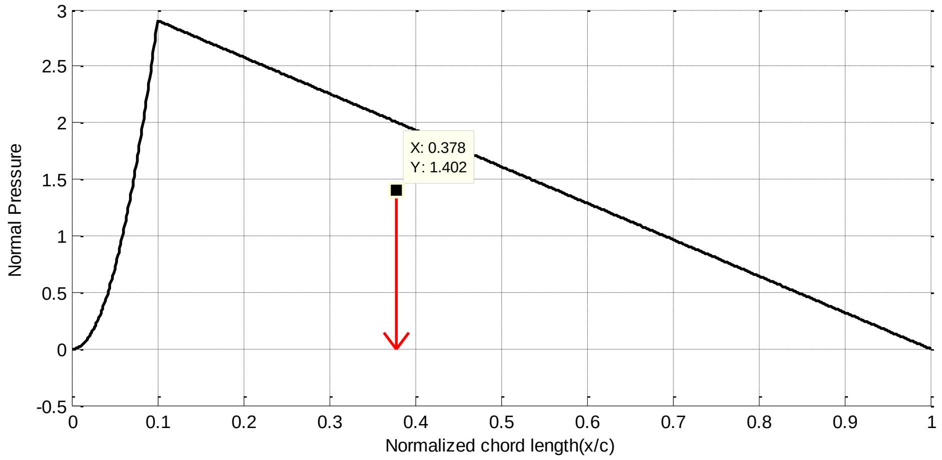


b. Calculate the normal force coefficient

$$C_p = C_{pl} - C_{pu} = \begin{cases} -0.95\left(\frac{x}{c}\right) + 300\left(\frac{x}{c}\right)^2 & for \quad 0 \le \left(\frac{x}{c}\right) \le 0.1 \\ 3.2277 - 3.2277\left(\frac{x}{c}\right) & for \quad 0.1 \le \left(\frac{x}{c}\right) \le 1 \end{cases}$$



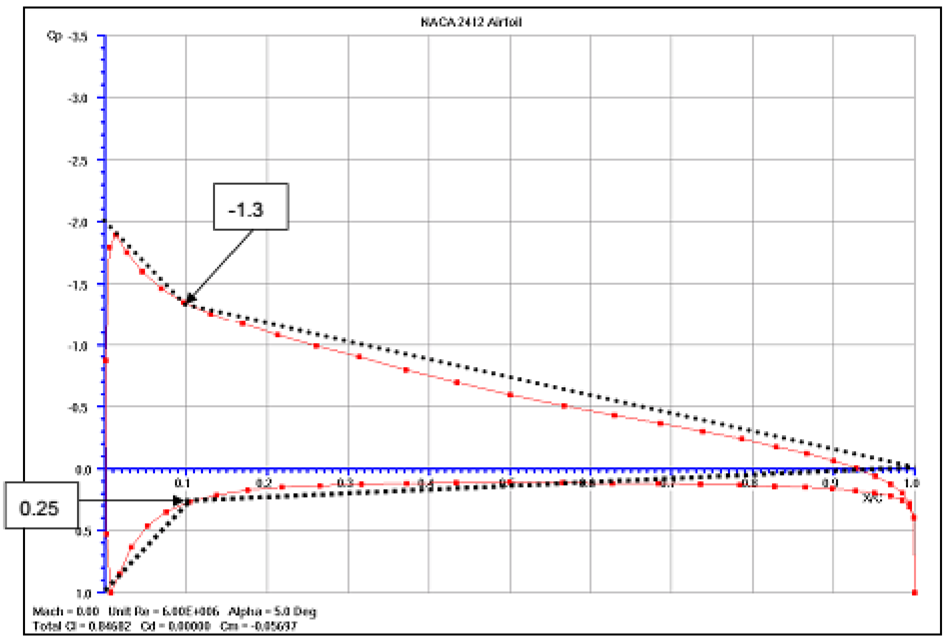
c. Calculate the location of center of pressure



Xc = 0.378

F = 1.402

4. The figure shown below represents the pressure distribution on a NACA2412 airfoil section at α = 5 degree. For a quick estimation of lift coefficient, these curves are approximated as the dotted line as shown.



a. Find the estimated value of lift coefficient

$$C_{pu} = \begin{cases} -2 + 7\left(\dfrac{x}{c}\right) & for \quad 0 \le \left(\dfrac{x}{c}\right) \le 0.1 \\ -1.4444 + 1.4444\left(\dfrac{x}{c}\right) & for \quad 0.1 \le \left(\dfrac{x}{c}\right) \le 1 \end{cases}$$

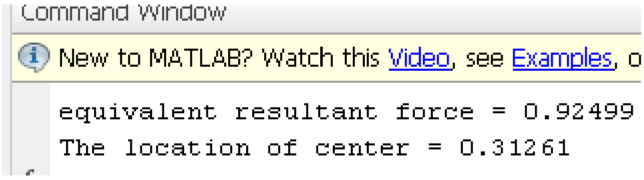
$$C_{pl} = \begin{cases} 1 - 7.5\left(\frac{x}{c}\right) & for \quad 0 \le \left(\frac{x}{c}\right) \le 0.1 \\ 0.2777 - 0.2777\left(\frac{x}{c}\right) & for \quad 0.1 \le \left(\frac{x}{c}\right) \le 1 \end{cases}$$

$$C_{p} = \begin{cases} 3 - 14.5\left(\frac{x}{c}\right) & for \quad 0 \le \left(\frac{x}{c}\right) \le 0.1 \\ 1.7222 - 1.7222\left(\frac{x}{c}\right) & for \quad 0.1 \le \left(\frac{x}{c}\right) \le 1 \end{cases}$$

b. Find the estimated location of center of lift

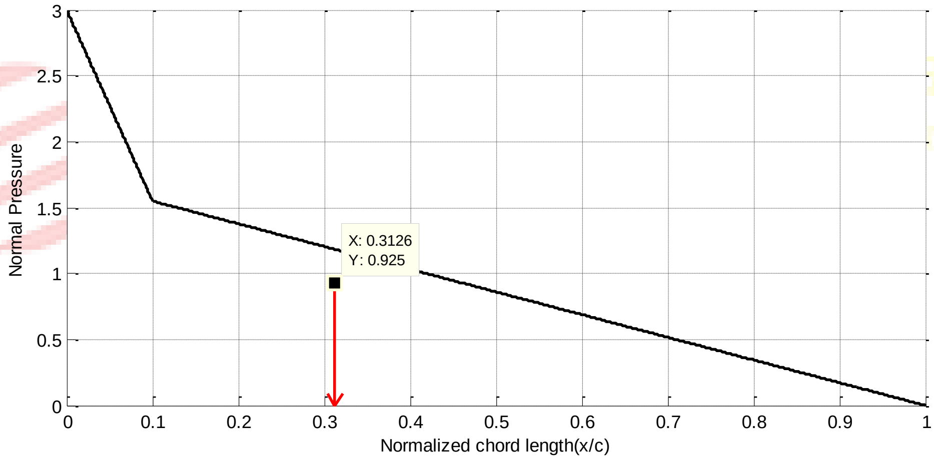
Force: 0.9250

Location of the center: 0.31261


Command Window

New to MATLAB? Watch this Video, see Examples, o

```
equivalent resultant force = 0.92499
The location of center = 0.31261
```



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